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ON THE COURSE AND DESTINATION OF GOWERS' TRACT.[1]

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THE literature on the anatomy of Gowers' tract is not very extensive, and a large proportion of it being principally of historical interest will not be here considered.

Gowers first described his antero-lateral tract in an address delivered in October, 1879, to the Medical Association of Wolverhampton,[3] and later in his diagnosis of the diseases of the spinal cord, 1880, p. 13 (v. also his Diseases of the Nervous System, 1892, Vol. I., p. 183).

Up to this time it had been confused in the cord with the direct cerebellar tract, but two distinct bundles, presumably of this latter tract, had been recognized in the medulla for some time by Meynert,[4] Flechsig,[5] and

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[1] The first part of the work upon which this paper is based was done in the pathological laboratory of University College, London, for the privileges of which I am indebted to Mr. Victor Horsley. The material was kindly furnished me by Professor Robert Boyce who had operated upon the animals for other purposes. To these gentlemen I wish to express my sincere thanks for these, as for many other courtesies. The work was finished in the pathological laboratory of the Chicago Policlinic.

[2] Presented to the American Neurological Association, May, 1895.

[3] *Medical Times and Gazette*, Nov. and Dec., 1879.

[4] *Arch. f. Psych u. Nerv.*, IV., 1873.

[5] *Leitungsb. im Geh. u. Rück.*, 1876, p. 326.

others, a dorsal bundle which passed backward along the periphery to occupy the corpus restiforme, and a smaller ventral bundle which occupied a position between the olivary body and the ascending root of the fifth nerve. The former was known to pass into the middle lobe of the cerebellum, but the termination of the latter was not definitely settled. Gowers did not consider the fibres of the antero-lateral tract to have any relation to this ventral bundle, a possible connection evidently never having occurred to him as he traced his tract only to the upper part of the cervical enlargement, and did not even formulate a supposition as to its further course. This connection was discovered at about the same time by Bechterew[6] and Leowenthal.[7] The latter considered it to be a part of the direct cerebellar tract, but the former described it as a distinct system on developmental grounds, the fibres receiving the medullary sheath at a different period from the other parts of the lateral column. He followed it, however, only to the lateral nucleus of the medulla and inferred that it terminated here. V. Monakow by means of Gudden's method had previously traced it somewhat higher, to the exit of the trigeminus, and thought it probably passed into the lateral fillet. Flechsig, indeed, although not tracing it so high, had expressed the same opinion. Many recent writers[8] still consider this tract as terminating in the pons. The findings of Loewenthal must receive more special mention as he followed these fibres far above all previous observers and traced out a course sufficiently long and tortuous to have attracted more attention. He deserves the more credit for his work in that he had not the advantage of the more recent technique (Marchi's method), but used a carmine stain. His investigations were made on two dogs, the spinal cords of which had been divided by Schiff, the one between the second and third cervical segments, the other between the fifth and sixth cervical. The accuracy of his deductions might be said to have been vitiated by the fact that the dog which furnished all the sections from the higher levels had undergone, in addition to his spinal section, an operation on the cerebral hemisphere opposite to the side of the cord lesion. Loewenthal found that at the level of the striæ medullares the direct cerebellar tract had divided into two distinct bundles, the one occupying the corpus restiforme dorsal to the ascending root of the fifth nerve, the other ventral to the same, there being no degenerated fibres between them. Just distal to the exit of the fifth and where the corpus restiforme with the dorsal bundle had passed into the cerebellum, another degenerated bundle make its appearance medial, and dorsal to the brachium conjunctivum,[9] while the ventral bundle was still to be found in its former place at the periphery, opposite the upper olive.

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[6] *Neurol. Centralb.*, 1885, pp. 155 and 341.

[7] *Rev. Med. de la Suisse Romande*, 1885, pp. 382 and 511. (There is a very fair abstract of this paper by v. Monakow in *Neurolog. Centralb.*, 1886, p. 56),

[8] Bechterew, Van Gehuchten, Obersteiner, Edinger, Von Lenhossek.

This new bundle, furthermore, lay lateral and a trifle dorsal to the fourth ventricle and vermis anterior (superior), and between fibres that were dorsal to the brachium conjunctivum and passed ventrally and laterally around and into it. The fibres of the bundle were cut partly transversely and partly obliquely. At the level of the exit of the fifth nerve the ventral bundle, owing to an increase of transverse pontine fibres, lay deeper from the lateral surface and had also moved somewhat dorsally. The brachium conjunctivum occupied the upper part of the isthmus, that is, the region of the isthmus situated above its lateral groove and the new dorsal bundle lay exactly dorsal to it. From here proximally the ventral bundle moves more laterally and dorsally just median to the most internal fibres of the middle cerebellar peduncle, traverses the most lateral part of the tegmentum and came to the surface at the lateral groove of the isthmus, being no more covered by the pontine fibres. These fibres were contiguous to the fillet, but never entered it. Leowenthal then infers that this bundle passes to the cerebellum, but could not demonstrate it.

From this time until the appearance of Mott's paper[10] the investigations of this subject may be largely neglected as no distinct addition was made to our knowledge and the conclusions of Loewenthal remained unconfirmed except by Auerbach. (Anat. Anzeiger, 1890, and Virchow's *Archiv*, Bd. 121, 1890, p. 199).

He not only confirms in the main the findings of Loewenthal, but follows the ventral bundle to the immediate neighborhood of the roof nucleus of Stilling of the opposite side, a few fibres going to the nucleus of the same side. The dorsal bundle, he concludes, ends in the dorsal part of the superior vermis, principally of the same side, and but few parts of the middle lobe are supplied by fibres from both bundles. He does not agree with Loewenthal that both belong to the direct cerebellar tract, but believes them to be two separate systems differing in origin, course and distribution.

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[9] In this paper the term "brachium conjunctivum" will be applied to the bundle of fibres joining the cerebellum to the corpora quadrigemina (Bindearm). while the ridge of tissue as a whole, the *processus e cerebello ad testis*, will be called the "peduncle" or "crus."

[10] *Brain*, 1892, p. 215.

Motts's experiments were made on two monkeys, in the first of which he made a section of the antero-lateral tract of either side in the mid-dorsal region and in the other a section of the same tract on the right side at the third cervical segment. Marchi's stain was used. He also had at his disposal the preparations made by Schäfer from two monkeys in which he had performed hemi-sections of the cord in the dorsal region. The cuts in Quain's Anatomy (Vol. III, p. 33) which illustrate the course of the antero-lateral tract were made from these preparations. They were also stained according to Marchi and are said by Mott to agree with his own. He describes the usual division into two bundles and notes that in the pons not only do the degenerated fibres of the ventral bundle form islets between the arciform fibres but that median to the compact area are some scattered fibres, and these he believes to be the same which he finds as high up as the anterior corpora quadrigemina, lying near to and external to the fillet. This will be referred to again. "At the level of the origin of the fifth nerve the fibres (*i. e.* of ventral bundle) become oblique and form a loop over this nerve; and posteriorly where the isthmus of white substance connects the superior cerebellar peduncle with the cerebellum, degenerated fibres can be seen entering the anterior portion of the superior vermis (the roof nucleus of Stilling)." "Still higher, just behind the posterior corpora quadrigemina, a tract of degenerated fibres is seen covering the superior peduncle of the cerebellum and continuous with the valve of Vieussens, into which some few degenerated fibres run." "The dorsal cerebellar fibres could be traced from the restiform body into the dorsal portion of the superior vermis, whilst the ventral portion was found as described by Loewenthal and Auerbach to take a much more circuitous course. In the pons they leave their ventral situation forming a loop over the fifth nerve, they are then directed obliquely upwards and backwards on to the surface of the superior peduncle, forming a layer of fibres continuous with the valve of Vieussens and separated from the peduncle by a thin layer of gray matter, they then run downwards on the superior surface of the peduncle as far as its junction with the cerebellum at the isthmus, where these degenerated fibres can be seen streaming inwards to the superior vermis." He does not give the relations of the direct cerbellar to Gowers' tract.

Tooth (*Brain*, 1892, p. 397.) made "a small dorso-ventral incision in the lateral region on the right side" between the first cervical root and lowest portion of the medulla of a monkey, killed the animal after thirty-four days and stained by the Weigert-Pal method. He traced the ventral bundle as high as the superior cerebellar crus but not into the cerebellum.

The material for my own investigations was supplied by three cats. In the first a hemi-section of the cord was made in the upper dorsal region, in the others a complete section a little lower down. The animals were kept alive a number of weeks,[11] killed with chloroform, the brain and cord carefully removed, hardened in Müller's fluid, stained according to Marchi and cut in series.

As the Marchi method is beyond all doubt the method *par excellence* for studying secondary degeneration, a word as to the technique may be allowed. The tissue is first placed in Müller's fluid or bichromate solution but the hardening process need not be completed (as for Weigert), ten days to two weeks sufficing, if the pieces are not too large; the parts may, however, remain in this fluid for a long time without detriment. The staining is done in the piece before the sections are cut, but the pieces must be thin, not to exceed two or at most three millimetres, and they remain in the stain ten days to two weeks. The solution consists of two parts of Müller's fluid or three per cent. solution of potassum bichromate and one part of a one per cent. solution of osmic acid.

Dehydration, embedding in celoidin, cutting, not too thick, clearing in carbolic xylol and mounting in Canada balsam, complete the process. Degenerated fibres stain a dense, opaque black and are easily distinguished from the pale brown or yellowish brown of the remainder of the section. But the tissue must not remain too long in this osmic acid solution as normal fibres are then stained black and the degeneration is not so easily differentiated. This also renders the material very brittle and difficult to cut. Indeed this is apt to be the case in any event, and when possible the sections should be cut under alcohol. Scattered through the sections and particularly in the nerve trunks and where there has been post-mortem injury are black spots which may be mistaken for degenerated fibres. Ordinarily they are not so large nor so opaque as the latter and may be excluded with reasonable certainty, but they are at times very perplexing unless the fibres are cut lengthwise. A complete series is impossible with this method, if the pieces are large in diameter (as the pons with the cerebellum), because, as they are cut quite thin, they warp more or less in the fluid, and some part is always lost between the series of succeeding pieces. It is necessary to allow the celloidin plenty of time to permeate—two to three weeks—as the osmic acid makes the tissue very hard and impermeable. But the most important limitation of the method lies in the fact that the degenerative process must have passed ten days but not exceeded three months in duration.—about six weeks being the most favorable period. This greatly restricts its use in the examination of the pathological material from clinical cases, but it is to be hoped that in suitable cases the method will find a wider adoption.

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[11] **I have unfortunately mislaid the notes giving the exact time.**

I shall not consider the origin of the antero-lateral tract, nor the question as to whether fibres pass to it from the same or opposite side, and if the latter, whether they pass by way of the anterior or posterior commissure. Neither shall I discuss the physiology of the tract, but I may remark that although this is as yet undetermined, the opinion expressed by Gowers and Bechterew that it conveys painful expressions is entirely without foundation in evidence, and almost certainly wrong.

The position of this tract in the cord is so well known as to need no lengthy description. It lies along the periphery immediately in front of the direct cerebellar tract from which, its fibres being of the same large calibre, it is not to be distinguished in appearance, and extends as a narrow seam forward almost, or quite to the most lateral of the anterior nerve-roots, not to the anterior pyramidal tracts as first described by Gowers. At its posterior or dorsal end, in front of the direct cerebellar tract, it sends a small projection medianwards which gives a transverse section of the entire tract somewhat the shape of a comma, head dorsally, tail ventrally. At the lowest part of the medulla oblongata, before the central canal has opened into the fourth ventricle (Fig. 1.) the direct cerebellar and anterior-lateral tracts (herein-after designed by d. c. and G. respectively) occupy approximately the same positions as in the cord, except that as the posterior horn (substantia gelatinosa Rolando) has been pushed laterally and forward by the nuclei of the columns of Goll and Burdach, it in turn has pushed the d. c. in the same direction, the latter lying almost exactly in the middle of the lateral periphery, largely condensed into a round head with a more slender cauda extending ventrally. This latter blends with G. which also extends nearer to the anterior median fissure than before but has almost lost its comma-like median projection. At a slightly higher level (Figs. 2 and 3) the substantia gelatinosa Rolando has receded somewhat from the periphery to allow room for the ascending root of the fifth nerve, and at this point the compact part of d. c. suddenly breaks and the fibres pass rapidly in a dorsal direction along the periphery towards the future corpus restiforme. This gives it again a comma-like shape but with the tail in the opposite direction. At the same time, while retaining its relative position, G. becomes more scattered. As we reach higher levels the fibres of the d. c. continue to pass dorsally until not only has the head of the comma ventral to the substantia gelatinosa Rolando disappeared, but there is almost a complete hiatus between this (d. c.) and the ventral bundle, G. (Figs. 4 and 5.)[12]

Indeed the d. c. now again forms a comma, the head being in the restiform body and the tail extending ventrally along the periphery external to the ascending root of the fifth. (Figs. 5 and 6.)

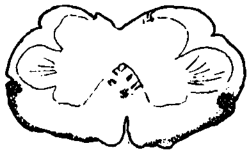

FIG. 1.

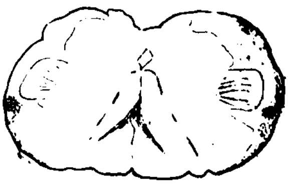

FIG. 2.

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[12] **At one place lower down (level of first hypoglossus fibres), d.c. and G., are quite separated by the lower lateral nucleus, but as soon as this**

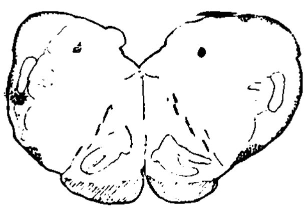

FIG. 3.

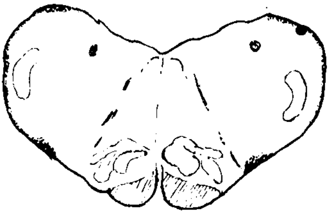

FIG. 4.

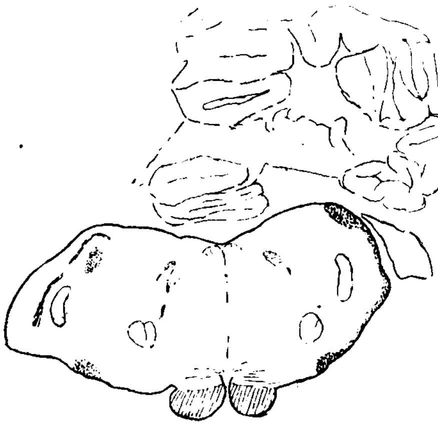

FIG. 5.

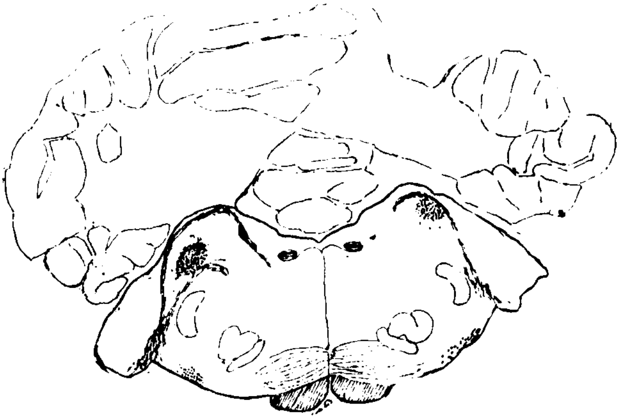

FIG. 6.

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disappears they show a tendency, for a short extent, to blend again but never make a distinct union.

At the exit of the glosso-pharyngeal, the corpus restiforme is well formed and includes nearly all of d. c., but a few straggling fibres may still be seen in the very narrow band of tissue between the ascending root of the fifth and the periphery, connecting d. c. with G. which now forms a compact bundle on the periphery, lateral to the upper lateral nucleus and well removed from the trigeminal root. A little higher, (Fig. 6) as the fourth ventricle widens out d. c. takes up a position rather more lateral than before and is less compact. G. is also more scattered, being cut up into disseminated groups by the arcuate fibres and spreading out dorsally toward the ascending fifth as well as medially. This is the level at which Mott distinguished the more median of the scattered fibres as a separate group which he finds later in the anterior corpora quadrigemina, without showing how they got there. At the levels represented by (Figs. 6 and 7) the dorsal part of the lateral auditory root circles about the restiform body making it and consequently d. c. more compact. A trifle higher, also to be seen in Figs. 6 and 7, d. c. and G. are completely and distinctly separated by fibres which come to make up the auditory nerve and soon the emerging root of this nerve with various fibers and nuclei sweep away all trace of scattered degenerated fibres between the two. At the same time G. shows a tendency to become more compact and to move rather more dorsally although the direction of its fibres cannot be seen to change; they are cut squarely transversely. By the time we reach the beginning of the origin of the seventh nerve, Figs. 7 and 8, (root-fibres of the sixth can also be seen) it (G.) has moved still more dorsally and forms a compact bundle on the periphery immediately ventral to this nerve-root. This position it holds until after the exit of the fifth. At about this level or a trifle below we see the first of degenerated fibres in the ventral part of the superior vermis. The inferior worm does not extend so far forward (upward) as this. These fibres are first seen wholly within the vermis, along the dorsal part of the lingula, and apparently start from the line of union of this with the superior cerebellar peduncle, dorsal to the point where the roof of the ventricle, the velum medullaris anterior, joins the side. A little higher they are seen to start from the crus side of this line of union and with them we meet with the first of the fibres of the brachium conjunctivum which pass to the middle cerebellar lobe,—supposing these fibres to come from above (corpora quadrigemina), down to the cerebellum. Most of them go to the middle lobe dorsal to the degenerated group, but a few are seen ventral to it. At a slightly higher level, Fig. 9, the fibres of the brachium are seen to pass in two directions, medianwards into the middle lobe and in a curve dorsally and laterally into the hemisphere over d. c. which is still a

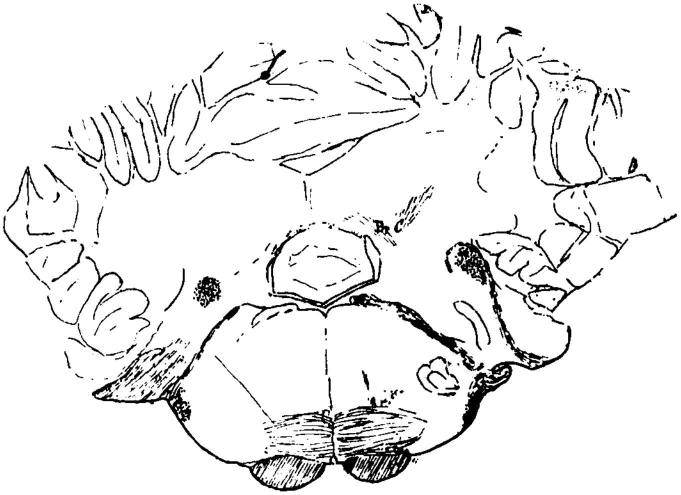

FIG. 7.

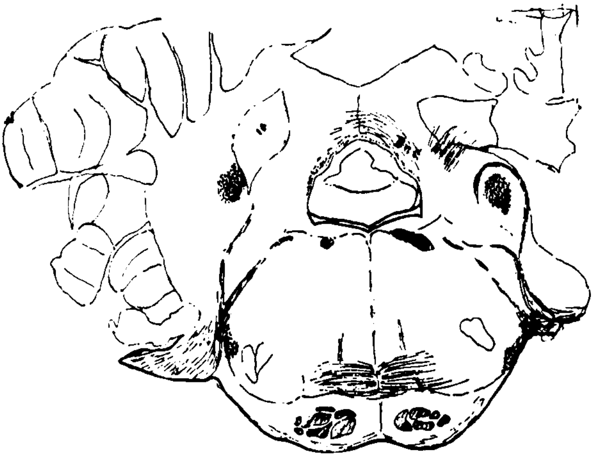

FIG. 8.

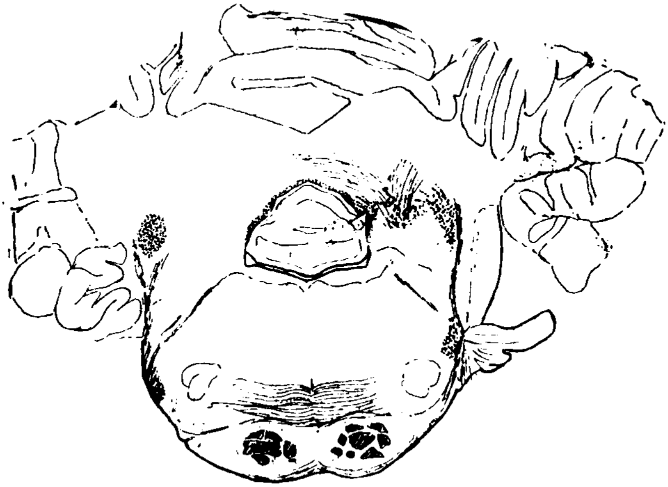

FIG. 9.

rather compact, bundle but has moved dorsally considerably beyond the level of the floor of the fourth ventricle. At this level can be distinctly seen fibres of the middle cerebellar peduncle, passing lateral to d. c. to reach the dorsal part of the middle lobe, although, more ventrally, the transverse fibres of the pons cannot be seen to have reached the cerebellum. That is, some of these fibres having reached the cerebellum curve in a caudal direction. As we shall see, this is characteristic of fibres coming to the cerebellum from below. Here the group of degenerated fibres lateral to the vermis has augmented considerably, and forms a triangular area, apex ventral, base dorsal. At Figs. 8 and 9, exit of the fifth, G. begins to straggle dorsally but cannot yet pass the descending root of the fifth which lies on a slightly higher level than the main trunk, d. c. is still rather compact but lies further dorsally and laterally and ventral to a large nucleus (corp. dentat.?). The group of degenerated fibres lateral to and passing into the worm is still larger. The sections represented by Figs. 9, 10 and 11 are most interesting as they are cut (accidentally) obliquely, one lateral half being on a higher level than the other. On the lower side fibres of the brachium are seen as two broad tracts passing, the one to the vermis, the other to the cerebellar hemisphere. On this side d. c. is still an unbroken group of fibres lying lateral to those of the brachium which go to the hemisphere. But on this side many degenerated fibres are seen streaming into the middle lobe. It will be seen at once from the other (higher) side that these fibres come from the d.c., having curved around those of the brachium, their course being first proximal and dorsal, then median and then in a more or less retrograde direction caudal-wards. In the meantime the triangular group of degenerated fibres in the crus lateral to the lingula has been growing; particularly the more dorsal fibres, those across the base of the triangle, have been getting longer and are cut almost longitudinally as they pass into the ventral part of the worm. With them, as well as dorsal and ventral to them, pass fibres of the brachium conjunctivum. The vermis is filled with degenerated fibres and the d. c. bundle has broken and is seen to spread out dorsally and towards the middle line, the picture being suggestive of the stream from a sprinkling pot, but there is a clear space between these two areas of degeneration made up mostly of peduncular fibres, which shows how d. c. fibres make a curve or loop around those of the branchium. We have already seen that some of the fibres of the middle cerebellar peduncle make a similar proximo-distal loop, and we shall see that G. makes a like curve. It might be inferred from this section, but can be seen better a little higher, Fig. 11, that a good part of the fibres of the degenerated area at the crus-lingula-junction, comes from d.c. as it spreads out, and go distinctly to the ventral part of the vermis. Owing to the before-mentioned curve made by d. c. it is impossible to say exactly what proportion of this triangular bunch (which we might call G") is derived from it. The side of the sections (Figs. 11, 12 and 13) showing this falls just distal to the point where the superior crus joins the cerebellum (proximal to the place where fibres of the brachium pass to vermis and hemisphere); that is, immediately below the isthmus, and even when the seperation of the crus from the cerebellum is complete these fibres of d. c. are still quite numerous, showing that some fibres of this tract ascend as far proximally as the isthmus before turning back distally into the cerebellum. They at the same time curve over the brachium conjunctivum, forming indeed a triple knee, or curve in three planes, one proximo-distal, one latero-median and one ventro-dorsal, quite anologous to, but less pronounced than that of the root-fibres of the facial nerve and almost identical with that of Gowers' tract, as we shall immediately see.

Numerous other fibres of d. c. go to the dorsal part of the worm, principally of the same side, partly to the opposite. Those distributed to the ventral part pass largely to the opposite side.

As remarked, the proportion of the degenerated area alluded to as "G," derived from d.c., can not be determined and the question arises whether all its fibres do not come from this tract. To answer this we must return

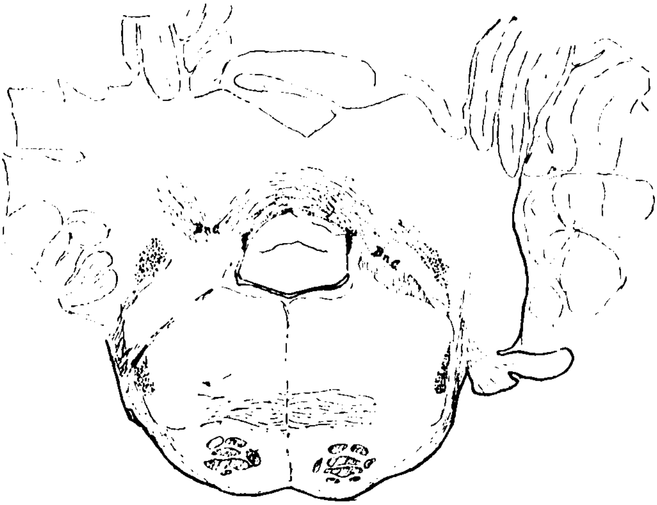

FIG. 10.

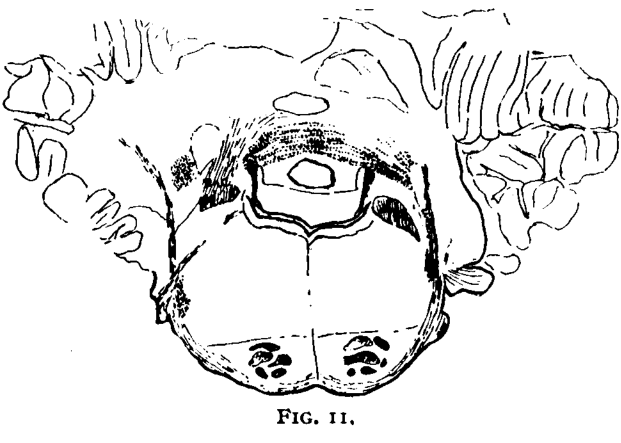

FIG. 11.

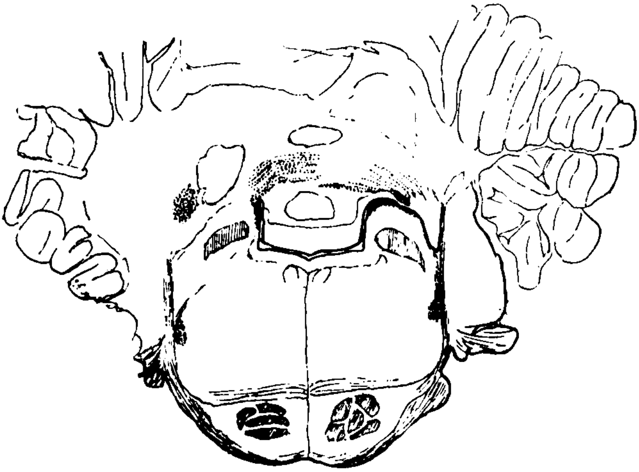

FIG. 12.

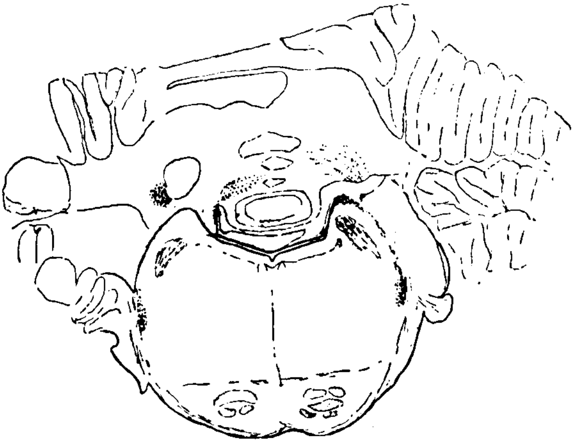

FIG. 13.

to G. Immediately the root of the fifth has made its exit (Figs. 11, 12, 13, 14[13]), this bundle starts to move dorsally, assuming a comma-like or triangular shape with the base ventral, the apex directed dorsally. As it moves dorsally just within the transverse pontine fibres (middle cerebellar peduncle), the apex or tail of the comma becomes more elongated until it nearly reaches the most ventral part of d. c., which is here fan-shaped —apex ventral—showing that the two tracts are very closely associated in this part of their course. This may account for the fact that Sherrington, quoted by Auerbach, traced G. into the restiform body. G. proceeds more and more dorsally as the remains of d. c. also recede dorsally and toward the middle line, until at the isthmus (Figs. 12, 13, 14, 15, 16, 17, 18), it lies along the periphery of the crus, the broadest part of the ventral extremity of the same, the tail reaching almost or quite to the apex. Covering this apex, or a little to the lateral side is a bunch of degenerated fibres which becomes rather more lateral and ventral in position as G. becomes rather more dorsal and median, until the isthmus of degenerated fibres connecting the two groups is about as wide as they, and we have a well-marked band of degenerated fibres cut almost longitudinally lying along the dorso-lateral periphery of the superior cerebellar peduncle (Figs. 17, 18, 19, 20). In other words, G. has been seen to pass from its position ventral to the ascending root of the fifth nerve, dorsally and proximally, until it forms a group as just described. As seen by the sketches 20, 21, 22, this group rapidly disappears as we ascend, remaining in the same position and the fibres being always cut longitudinally or quite obliquely, except at the ends of the group, so that some distance

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[13] Figures 14 to 20 are reversed so that the right side corresponds to the left in the other figures.

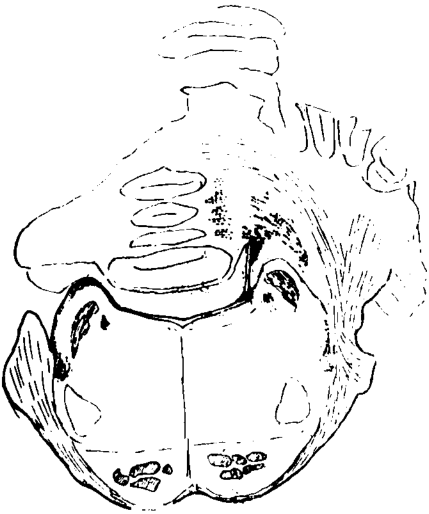
FIG. 14.

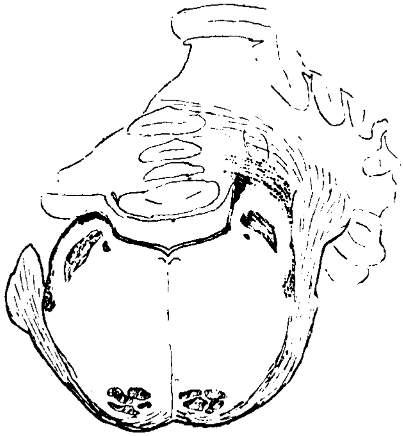
FIG. 15.

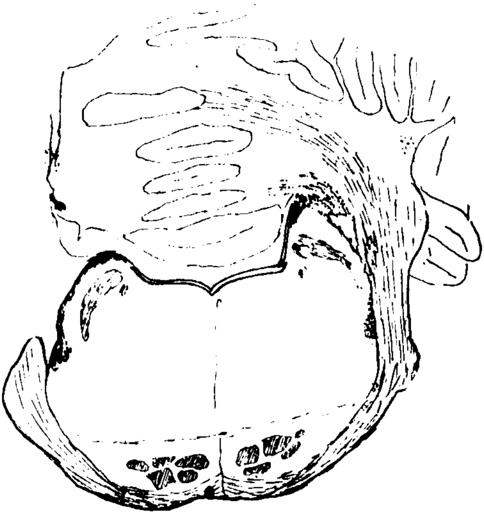

FIG. 16.

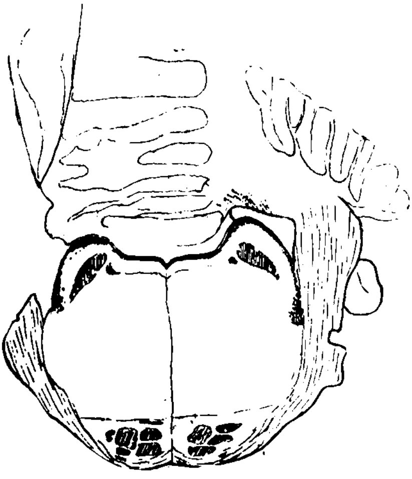

FIG. 17.

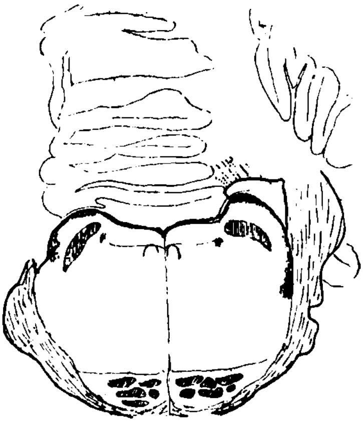

FIG. 18.

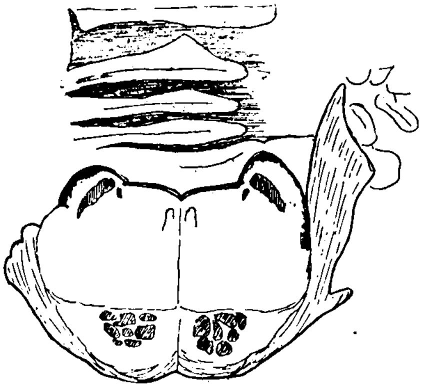

FIG. 19.

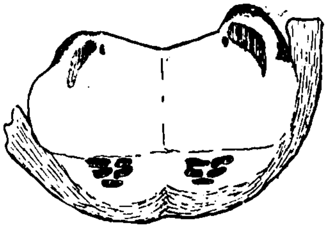

FIG. 20.

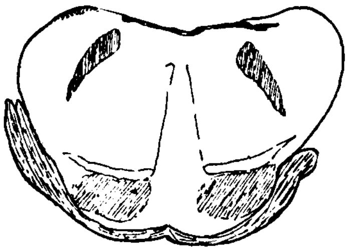

FIG. 21.

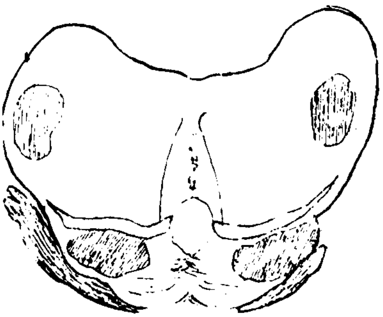

FIG 22.

below the posterior corpora quadrigemina and before the fourth ventricle terminates in the aqueduct of Sylvius, no sign of it remains. I find no trace of the degeneration in the anterior corpus quadrigeminum described by Mott. It was probably an artifact; certainly had no connection with Gowers' tract. If from this level we again study the sections in a descending series, this cap on the crus is observed to move first medianwards until it lies exactly on the apex. In this position it is separated from the brachium by a layer of normal fibres, intermixed with more or less gray matter (more above, less below), which course around the brachium parallel to the surface of the crus. On the median side of the brachium they turn in a cephalo caudal direction (are cut transversely), and look as if they might come from a location median to d. c., or constitute a continuation of transverse pontine fibres; or possibly they belong to the direct sensory cerebellar tract described by Edinger, although they are not exactly in the location described by this author. Lower, the *degenerated* area is found on the medio-dorsal periphery of the crus, and here it assumes the triangular shape, base dorsal, apex ventral, observed from this downwards almost to its disappearance. Slightly lower, as before mentioned, we can easily trace the connection of the most dorsal fibres, those of the base of the triangle, with d. c. (Figs. 21, 20, 19, 18, 17, 16), but with the more ventral ones no such union can be found, neither above nor below, and we are forced to conclude that they are a continuation of the fibres which capped the peduncle. That is, we have traced G. to a termination in the ventral and more distal part of the vermis superioris cerebelli, at least distal to the distribution of d. c.

The course of these fibres has been considered as very remarkable by Loewenthal and Mott, but I cannot look upon it as such,—at least in comparison with other tracts of the nervous system, notably parts of the lemniscus, the root of the seventh nerve and some of the root fibres of the auditory. It is described by the two authors just mentioned as looping back over the root of the trigeminus, but as a matter of fact it passes from this point still further proximally and turns back only when it has reached the isthmus, and this loop, as we have seen, does not much exceed in extent that made by d. c., and this exceeds only slightly that made by fibres of the middle cerebellar peduncle. The fibres in the crus between G. and the brachium conjunctivum were also seen to make a similar loop. The most obvious explanation of these facts would be that the distribution of the fibres in question has been carried backward by the development caudally of the cerebellum. Bechterew has shown that in some animals at birth the only fibres of the cerebellum clothed with a medullary sheath are the direct cerebellar tract, and a system which he derives from the superior olive. This in all probability accounts for the curve of d. c. exceeding that of the middle peduncular fibres. It would seem to be definitely determined, although detailed evidence on this point is difficult to find, that Gowers' tract develops at an earlier period of fœtal life than the direct cerebellar tract.[14]

This, then, would account for its making a rather more pronounced cephalo-caudal loop than the latter. That is, having entered the cerebellum at an early period it would already have been carried backward somewhat, before the entrance of d. c. into this part of the brain.

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[14] Obersteiner: Nervöse Centralorgane, p. 250. Gowers: Diseases of the Nervous System, Vol. I., p. 170.

That the ventral bundle (G.) in the medulla is the continuation of Gowers' tract in the cord would seem sufficiently plain from a study of my sections, but more conclusive evidence is not wanting. Herzen and Loewenthal[15] made a section of the posterior half of the right side of the cord just below the medulla oblongata, leaving Gowers' tract uninjured, and the ventral bundle in the medulla was found normal, the dorsal bundle degenerated. The experiments of Mott were the converse. He cut the antero-lateral tract alone and found the ventral bundle in the medulla degenerated and the direct cerebellar tract (dorsal bundle) intact. Other experimenters have had similar results.

Whether the course of Gowers' tract in man corresponds to the foregoing results is yet to be demonstrated, but the similarity of the findings of Loewenthal in dogs, Schäfer, Mott and Tooth in monkeys, and of Auerbach and myself in cats, as well as the striking analogy of the anatomy of the tract in the cord and medulla would seem to indicate that it must be very nearly the same. In the new-born human subject the tract can be easily followed high up in the medulla, but at about the level of the origin of the auditory nerve so many other fibres invade this region that those of Gowers' tract are lost in the confusion. See N. B. 1, N. B. 2, N. B. 3, which are accurate sketches from sections in my collection. Unfortunately the investigations of pathological material in man have been in advanced cases, and by means of a carmine or

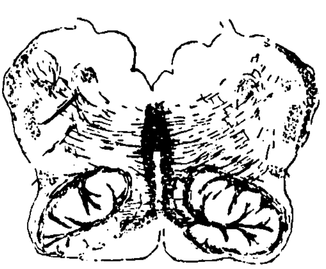

FIG. NB 1.

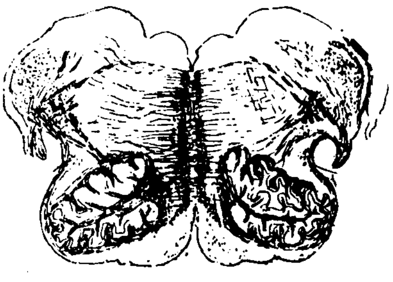

FIG. NB 2.

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[15] *Archives de Physiologie*, 1886, T. VII., p. 260.

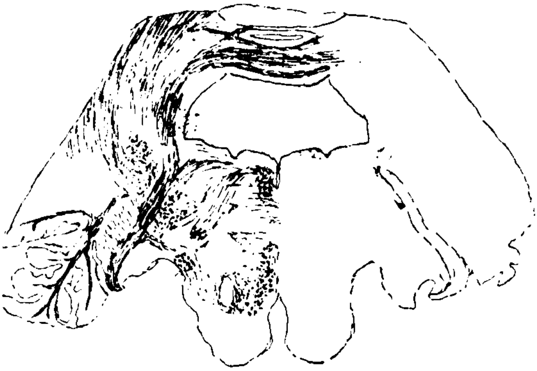

FIG. NB 3.

Weigert stain and prior to my own examination of a case of total transverse lesion of the cord (at upper dorsal and lower cervical regions) the degeneration had never been followed (in man) above the lateral nucleus of the medulla,—by Gowers, as stated, only to the cervical enlargement. My better success was

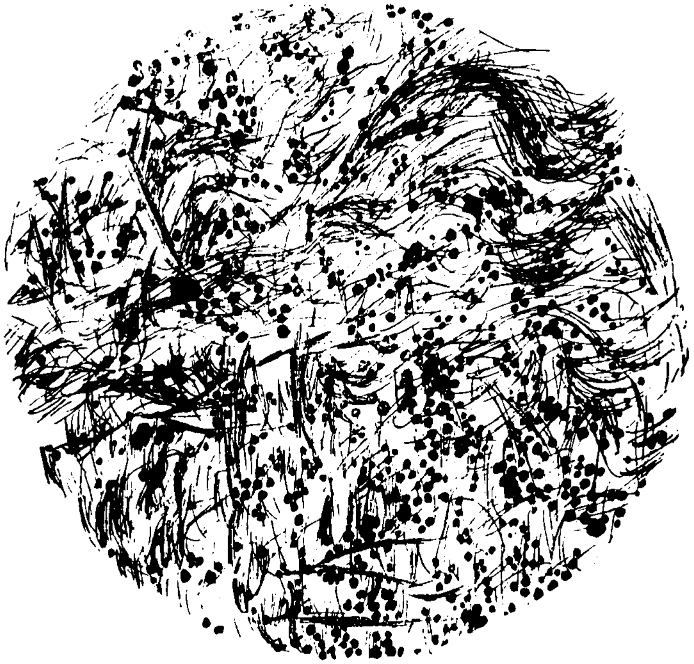

FIG. X.

doubtless due, as stated at the time,[16] to an exceptional result of the Weigert stain, for the period of degeneration (three and a half months) was such that a number of the degenerated fibres stained a uniform opaque black resembling greatly the effect of the Marchi method. See fig. X. which is taken from d.c. in lower medulla. (Weigert Pal stain). By this means I was enabled to trace Gowers' tract above the origin of the fifth nerve, possibly as high as the superior cerebellar peduncle but owing to imperfections in the material and to the fact that only a small minority of the affected fibres stained as stated, the character of the findings at the higher levels was somewhat uncertain. As far as traced with certainty the position of the tract corresponded exactly to that in the lower animals, except that the enormous middle peduncle of the cerebellum in man places it much further from the lateral and ventral surfaces in the pons. (Figs. I, II, III, IV, V.) taken from the case of crush of the cord alluded to, indicate the course of the tract.

Whether the antero-lateral tract constitutes a distinct system as Gowers, Bechterew and Auerbach contend or is to be considered as simply a ventral division of the direct cerebellar tract, I think must be left to physiological and pathological research; anatomy cannot decide it. Although they develop at slightly different periods, probably have not an identical origin, and run separate courses, they are similar in many respects. Their origin

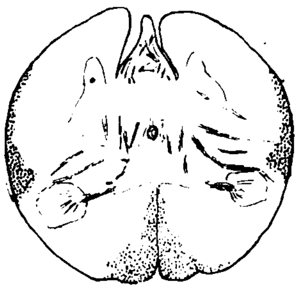

FIG. I.

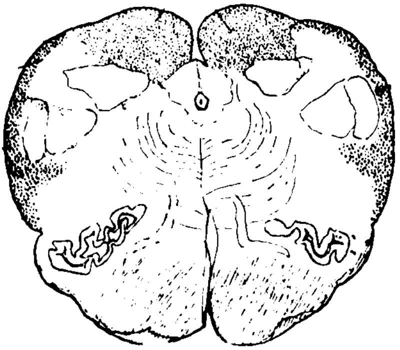

FIG. II.

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[16] Ueber aufsteigende Degeneration nach totaler Quetschung des Rückenmarkes. Arch. für Psych. u. Nerv. Bd.XXV. Heft 3.

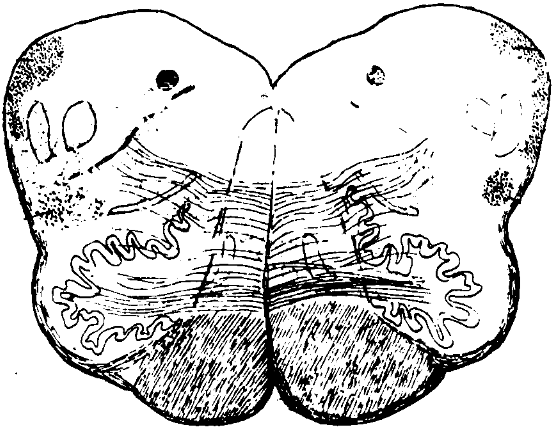

Fig. III.

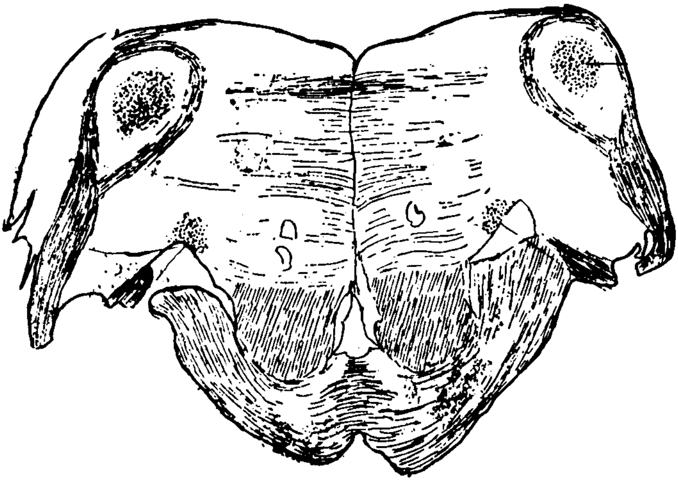

Fig. IV.

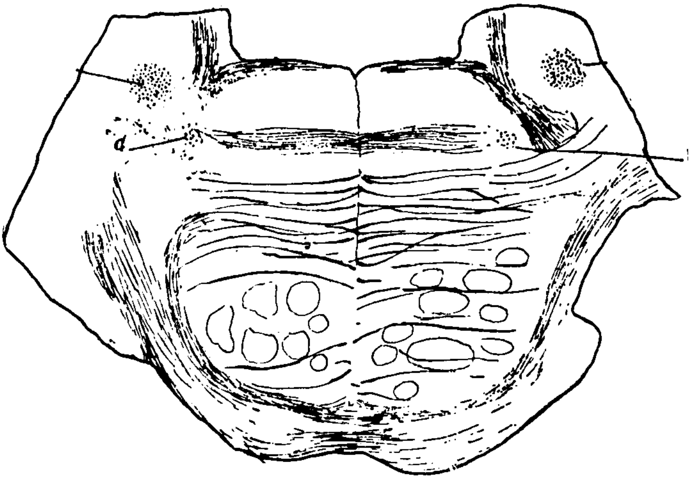

FIG. V.

is probably similar (posterior roots, through cells of posterior horns) their fibres are of the same calibre, and though separated from the medulla upward, they run side by side, even in the curved course to the cerebellum, and they blend in their distribution, as my sections plainly show, contrary to the dictum of Auerbach and Mott.

VENETIAN BUILDING.